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TITLE: Preliminary Beta/Gamma Radiological Survey and Data Analysis for the Sodium Disposal Facility Closure

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1.0 SCOPE

This document provides the procedures for performing the baseline Beta/Gamma radiological survey of the Sodium Disposal Facility (SDF) at Area IV of the Santa Susana Field Laboratory (SSFL). Included are the analytical techniques to be applied to the data obtained from the survey. The overall facility description and the technical approach to the closure are contained in Applicable Document No. 1.

1.1 PURPOSE OF THE SURVEY

The purpose of this beta/gamma radiological survey is to establish the baseline ambient radiation level of the SDF site in preparation for site remediation. The data from the survey will be used to identify areas where radioactivity exists at levels above normal background.

1.2 EXPECTED OUTPUT

All survey data will be tabulated by site location (given as **Northing** and **Easting** coordinates referenced to the California Plane Coordinate System).

The survey measurements will be evaluated to determine if any sample locations have an ambient (1 meter height) gamma radiation level greater than 5 μR/hr over the normal background radiation level for this region.

Survey locations exceeding the stated criteria level will be further listed on a separate table of suspected contaminated areas. The locations will be marked on a site map and boundary lines will be defined around the indicated radioactive areas.

At the conclusion of this work, the data tables and marked–up site maps will be used to define locations where representative soil samples will be taken for lab analysis to further define the isotopic content of the radioactive areas.

2.0 APPLICABLE DOCUMENTS AND REFERENCES

2.1 APPLICABLE DOCUMENTS

1. Closure Plan for the Former Sodium Disposal Facility at SSFL, Ebasco, July 1991

2. Health & Safety Plan for the Sodium Disposal Facility, W. R. Johnson 886–ZR–0001, January 1992

3. "Radiological Survey of the Sodium Disposal Facility – Bldg T886," J. A. Chapman, GEN–ZR–0004, 27 June 1988

4. "Guidelines for Residual Radioactivity at Formerly Utilized Sites Remedial Action Program and Remote Surplus Management Program Sites;" U.S. DOE, February 1985 (Rev. 2, March 1987)

5. "SSFL Area IV Sodium Burnpit Grid Layout Drawing," R. Padilla, Drawing No. 886–CN–0001, 6 January 1992

2.2 REFERENCES

1. Handbook of Radioactivity Measurement Procedures, Second Edition, NCRP Report No. 58, National Council on Radiation Protection and Measurement, Bethesda, MD, February 1985

2. Introduction to Health Physics, Second Edition, Herman Cember, Northwestern University, Pergamon Press, 1983

3. Radiation Protection: A Guide for Scientists and Physicians, Third Edition, Jacob Shapiro, Harvard University Press, Massachusetts, 1990

3.0 EQUIPMENT AND MATERIALS

3.1 SURVEY EQUIPMENT AND MATERIALS LIST*

4 ea. Ludlum Model 2221 or Model 2220–ESG Scaler/Ratemeters

2 ea. Ludlum Model 44–9 Thin–Window Pancake GM Beta (/Gamma) Detectors (see paragraph 3.2.2)

2 ea. Ludlum Model 44–2 High–Energy NaI Gamma Detectors (see paragraph 3.2.1)

Designated Field Check Source

Survey Log Book

2 ea. Sighting Compasses (Silva Type 27 or equivalent)

3 ea. 200 ft Fiberglass Field Survey Measuring Tapes

8 ea. Flagged Poles

3.2 PRESURVEY DETECTOR HARDWARE PREPARATION

3.2.1 Gamma Detectors

Prior to the start of the survey, the two sodium–iodide gamma detectors will be mounted side by side on a pole to fix them at 1 meter distance from the end of the pole. Use a 5–ft length of Schedule 40, 1 inch IPS, PVC pipe for the pole, and secure the detectors to the pole with duct tape.

3.2.2 Beta Detectors

The two pancake GM beta detectors will each be independently fitted with PVC collars that mechanically support the detectors at 1 cm distance from the ground when placed flat on the surface.

*Does not include personal protective equipment (see Section 4.0).

4.0 SPECIAL SAFETY PRECAUTIONS

Special safety precautions are in effect for the radiological survey work covered by this DWP.

The principle hazards at the SDF worksite include possible inhalation of vapors from residues of petroleum products and industrial solvents, and possible inhalation of dust particles containing residues of heavy metals, alkali metal oxides, and radionuclides.

Additionally, the work will require the use of specialized protective equipment, which restricts normal motion and makes the work more difficult. This may introduce a risk of heat stress, and increase the risk of tripping and falling injuries on the uneven terrain. Because of these increased work hazards, no work will be done in any of the controlled areas unless at least two survey team members are present.

If the survey team encounters a one–meter gamma reading greater than 5 μR/hr above background they will mark the location with a flag and note it on the Data Control Sheet before proceeding to the next survey location.

If the survey team encounters a gamma reading greater than 20 μR/hr above background in any area outside of the ponds area, they will also notify the survey manager and the Facility Manager before moving on to the next survey location.

4.1 SDF HEALTH AND SAFETY PLAN

The site Health and Safety Plan (H&S Plan) (886–ZR–0001) for closure of the sodium disposal facility contains detailed information on the specific hazards and associated protective equipment and procedures for all work at the site. Each person on the gamma survey team shall become familiar with the contents of the H&S Plan. A copy of the H&S Plan will be kept on–site in the site Engineering Trailer for ready access and referral.

4.2 SPECIAL PERSONNEL TRAINING REQUIREMENTS

All members of the radiological survey team must have proof of completion of the following training courses before entry into the site work areas:

24–Hour Hazardous Waste Operations and Procedures Course (4033/24)

SDF Site Familiarization Course

Hazardous Materials Communications Course

Hazardous Materials Handling Course

Radiation Safety Training Course (2013)

Respirator Protection Training Course [for the MSA (half mask) Comfo Respirator w/HEPA type MSA–H and GMA–H filter cartridges]

Additionally, all survey team members:

Must have 8–hours on–site on–the–job training, which may be concurrent with the survey;

Must have had a medical qualification exam and be currently on an annual medical monitoring program;

Must have read and thoroughly understand the radiological survey procedures detailed in Section 5.0 of this DWP;

Must certify by signature on the SDF H&S Certification Form that they have read the site H&S Plan, that they understand the nature of the hazards expected at the site, and that they are aware of the special protective equipment and procedures required for each of the controlled work areas.

4.3 ACCESS CONTROLS

Although no general site sign–in will be required, all survey crew members must check in with the Facility Manager and the Site Crew Chief before entering any work areas.

At the start of the survey, the Facility Manager will initiate and sign a Controlled Work Permit. Each survey team member will also sign the Permit.

At the start of each work shift, the Site H&S Officer will brief the survey team on current site hazards, and on specific procedural or Personnel Protective Equipment requirements that may be needed in the controlled areas.

4.4 PERSONNEL PROTECTIVE EQUIPMENT

The specific selection of Personnel Protective Equipment (PPE) to be used on the site may require a reevaluation and change during the course of the work. The current PPE needs will be detailed by the site H&S Officer during the safety briefing at the start of each workshift. The following protective equipment will be available for the crew:

In All Controlled Areas
Tyvex and Saranex coveralls
Steel–toed work boots
Gloves

Additional Requirements in the Upper and Lower Pond Areas
MSA Comfo half–face respirators w/HEPA type MSA–H or w/HEPA type GMA–H filter cartridges

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5.0 WORK INSTRUCTIONS

This section provides a detailed working procedure for performing a preliminary radiological survey of the Sodium Disposal Facility ponds, and adjacent areas. After a brief description of the overall survey plan, detailed instructions are given for determining survey locations; for survey data identification and record keeping; for data analysis and evaluation; and for survey instrument quality assurance.

During performance of this work, a single designated "working copy" of this detailed working procedure (DWP) will be utilized at the work site. Should procedure changes become necessary during the survey, the DWP "working copy" will be red–lined to reflect the changes. All changes to procedures must be approved by the Nuclear Operations Manager or his designee(s). Radiation Protection and Health Physics Services must approve and sign any changes affecting radiological health and safety, or survey methodology; the Program Manager must approve and sign any changes affecting cost or schedule; and Quality Assurance must approve and sign any changes affecting quality. At the completion of the survey, all red–lined changes will be incorporated into a revised version of the DWP and released through ETEC ASU.

5.1 SURVEY PLAN OVERVIEW

This section provides a brief description of the overall SDF radiological survey plan. This plan is comprised of detailed methodology for accurately determining the survey locations; for recording the survey data; for analyzing and evaluating the significance of the data against prescribed criteria; and for assuring that the survey instruments were performing normally during the survey.

The SDF radiological survey measurements will be made at preselected locations, defined by a measured grid. The individual survey points will be spaced at 10–ft intervals along both the north/south and east/west directions. The survey grid will be larger than, and overlaying, the two SDF pond areas, the Western area, and the areas North (and east) of the ponds. The boundaries of the radiological survey area have been determined by boundary survey specialists, and location stakes have been set on a grid at 50–ft intervals throughout the site. All of the grid locations are referenced to a surveyor's brass monument located east of the site. This monument marks a location on the California Plain Coordinate System at:

$$\frac{\text{N266,309.97}}{\text{E1,783,273.69}} \; *$$

*The 1975 brass monument itself lists North and East coordinates that refer to an arbitrary point within the SSFL boundary. The actual location on the State Plain Coordinate System was determined for this survey by Azimuth Boundary Specialists, Simi Valley, CA.

The individual survey measurement locations for this radiological survey will be identified by tape measurements from the grid reference stakes. To find the sample locations, the survey team will lay a reference measuring tape between two grid reference stakes just along the east/west axis north of the area being surveyed. Another reference tape will be similarly laid between grid reference stakes on the east/west axis just south of the area being surveyed. The survey team will find the "West" coordinate axis of the sample location (as distance west of the brass monument) by locating the desired 10–ft interval point on each of the two east/west reference measuring tapes, and laying a third measuring tape perpendicular to the first pair of tapes between the two points. This third reference measuring tape then lays along the north/south line that is described by the West coordinate axis for the survey location to be selected. The actual survey location may then be found by measuring along the third tape to the desired 10–ft interval. The radiological survey measurements will be made at the intersection of the West coordinate axis and at the North/South coordinate point. When the measurements are recorded, the sample location will be labeled by a bracketed pair of coordinate distance measurements referenced to the brass surveyor's monument. For example, if the brass monument is reference point [0,0] a survey location might be identified by a coordinate point such as [W180,S220], where the survey location is 180 ft west of the monument and 220 ft south of the monument. These reference distance coordinate points will be used to identify the sample locations in the field, and on the subsequent maps defining suspect radioactive areas. In the final report, the reference distances will be converted to **Northing** and **Easting** coordinate points on the California Plain Coordinate System.

This sample location and labeling scheme will provide permanent traceability of the physical location of each survey point into the future without need for individual marker stakes or monuments, and regardless of the site modifications that occur during decommissioning of the facility. Since the data will be entered into the computer database, this new grid layout and labeling format will provide a means for accumulating the results of this and future surveys into a comprehensive Area IV radiation environment status map.

The survey measurements at each survey location will consist of 1 minute measurements of gross gamma at 1–meter distance from the soil surface, along with measurements of gross beta at 1–cm from the soil surface. All measurements will be taken simultaneously with pairs of independent instruments: two gamma meters, and two beta meters. The beta survey is being conducted at the same time as the gamma survey because strontium–90 contamination near the surface might be detectable by the beta detector where it would certainly be missed by the gamma survey. All data will be labeled by location, and recorded on a Survey Data Control Sheet in the survey log book according to the instructions provided in Appendix B.

Making simultaneous survey measurements with paired, duplicate instruments provides a continuous check on instrument reliability to detect instrument instability, drift, intermittent excessive noise, or other failures. The availability of paired data also provides an improvement in measurement precision by a factor 1.4, while reducing the count time needed at each location by a factor of one–half.

Additionally, periodic checks of the instrument's performance with a Field Check Source, and routine estimates of the detector efficiencies based upon their responses, provides a means of monitoring for any changes in instrument accuracy during the test.

The data will be used to identify locations that have elevated radioactivity levels; the locations will be marked on a map, and boundary lines will be delineated around the radioactive areas. Representative soil samples will be taken from each radioactive area for lab analysis to further define their isotopic content.

5.2 DETERMINATION OF SURVEY LOCATIONS

5.2.1 Identification of SDF Survey Areas

For purposes of statistical analysis of the survey results, the facility will be divided into four areas. These areas are as follows:

1. Upper pond area (southernmost pond area)
2. Lower pond area (northernmost pond area)
3. West area (area west of the ponds)
4. North area (areas north and east of the ponds)

5.2.2 Procedure for Determining Survey Locations

5.2.2.1 Survey Grid Layout

The SDF site has already been surveyed, and marker stakes have been placed on a 50–ft x 50–ft interval grid (Document 5), relative to an already existing surveyor's brass monument located to the east of the SDF site. A map of the facility showing the 50–ft grid layout is given in Figure 1. Some of the area has been further provided with location marking stakes by a 10–ft x 10–ft interval grid; where available, these stakes will be used directly for finding the survey locations. Where the survey location is not marked by a stake, the following two paragraphs describe the procedure for establishing the coordinate axis description for any location in the 50–ft x 50–ft interval grid.

5.2.2.2 Establish East/West Coordinate Axis for the Survey Location

Starting at the surveyor's brass monument at the site reference point (location [0,0]), find the first 50–ft grid marker stake to the west (location [W050,0]). Starting at this first stake, lay a 200–ft reference measuring tape along the line of stakes running due

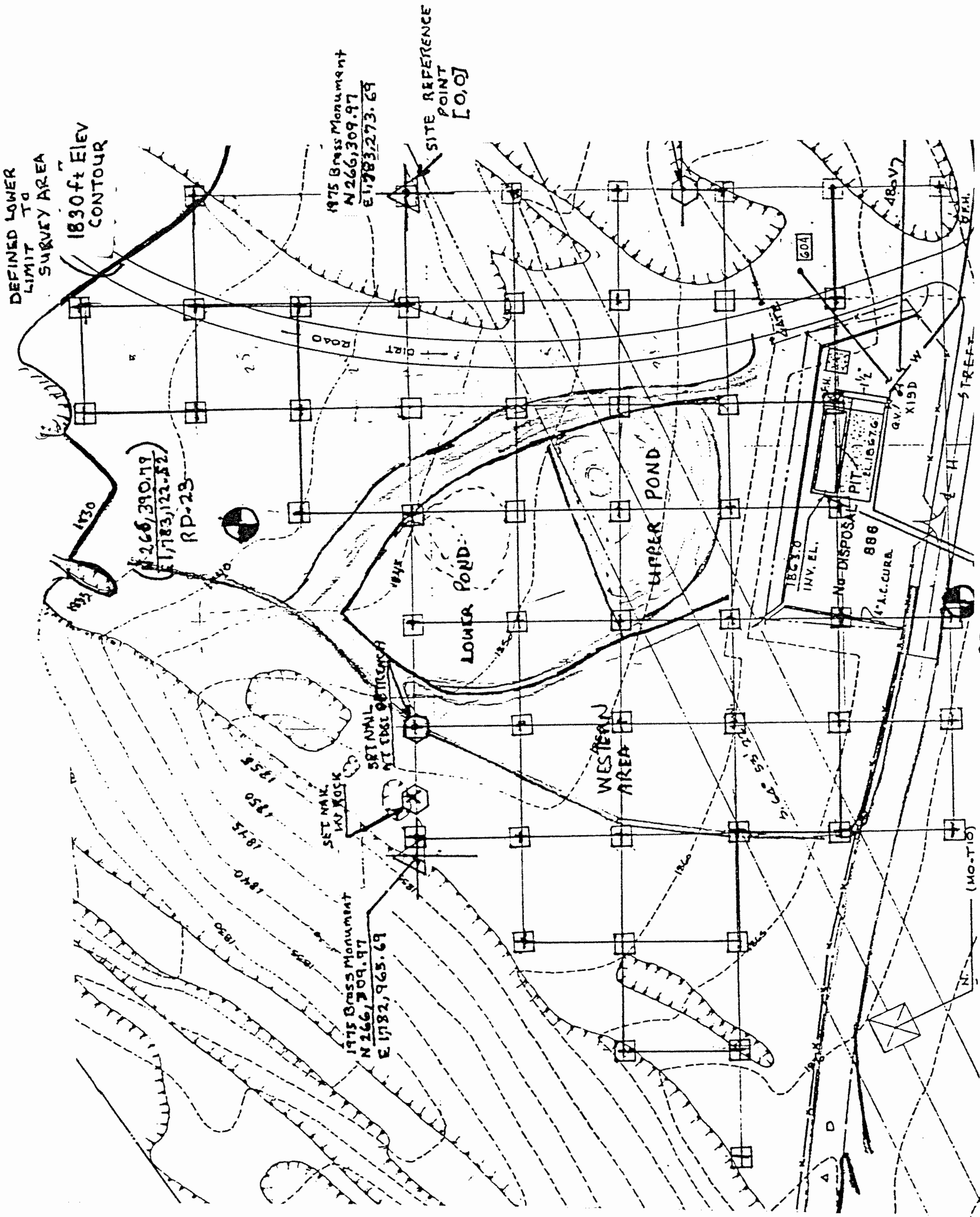

Figure 1. Site Schematic Showing Locations of the 50-ft x 50-ft Grid Marker Stakes

west of the brass reference monument; the measuring tape 200–ft mark should fall on the [W250,0] 50–ft grid marker stake.

Leaving the first measuring tape in place, find the 50–ft grid marker stake that is 50 ft west of, and 200 ft south of [W050,S200] the reference monument. Lay a second 200–ft measuring tape along the line of stakes running due west of stake [W050,S200]; the 200–ft reference mark of the second measuring tape should fall on the [W250,S200] grid marker stake. A specific location along the West coordinate axis of either of the reference measuring tape lines is found by adding the value of the distance mark on the measuring tape to the West coordinate distance value on the 50–ft grid marker stake being used as a starting point.

For example: A location on the first measuring tape at the 70–ft mark (i.e., 70 ft west of the tape starting point) would be equal to w70 + [W050,0] = [W120,0], which describes the location as being 120 ft due west of the reference monument.

Similarly, a location on the second measuring tape at the 70–ft mark would be equal to w70 + [W050,S200] = [W120,S200], which describes the second location as being 120 ft west and 200 ft south of the reference monument. A north/south line running between these two points lies along W120 West coordinate axis.

5.2.2.3 Establish North/South Coordinate Point for the Survey Location

Lay out a third 200–ft reference measuring tape running on a north/south line between the West coordinate axis points of the first and second tape lines. A specific survey location along the north/south coordinate axis can now be determined by adding the distance indicated on the measuring tape to the North (or South) distance coordinate value on the 50–ft grid marker stake being used as a starting point. The total distance North (or South) of the brass reference monument describes the location of the North/South coordinate point for the survey location.

For example: A location on the north/south coordinate axis at the 180–ft reference tape mark (i.e., 180 ft south of a starting point that is 120 ft due west of the brass reference monument) would be equal to s180 + [W120,0] = [W120,S180].

5.3 SURVEY INSTRUMENT OPERATING PROCEDURES

This section provides detailed instructions for calibration and use of the survey instruments.

Note: All non–normal observations and meter readings shall be reported to the survey manager.

5.3.1 Instrument Settings

For the Model 2220 and 2221 Ratemeter/Scalers:

WINDOW .... "OUT"
RESP (F/S) .... "F" (Fast time constant)
COUNT TIME .... * *Normal:*
[MINUTES = "1.0"
x1/x10 = "x1"]
RANGE .... * *Normal:*
[= "x1"--for Pancake GM beta probe
= "x10"--for NaI gamma probe]

*(Or, as need by the survey situation)

Additional note for the model 2221:
Set SCALER/DIG RATE ...... "SCALER"
LAMP ON/OFF .... "OFF"
AUDIO DIVIDE .... "1"
MINUTES .... "1"

5.3.1.1 Check the "calibration due" date on the calibration label.

Verify that the instrument calibration is still current.

5.3.1.2 Set the RANGE switch to "LOG" (for the model 2221, also set the POWER ON/OFF switch to "ON").

Observe that the analog meter pointer goes to maximum off-scale, then drops back to some mid-scale location.

5.3.1.3 Set the RANGE switch to the *normal* range setting for the detector probe being used.

5.3.1.4 Check the **battery condition** by pressing the **"BAT"** switch.

Observe the digital display reading from 5.8 to 6.4 (0580 to 0640).

5.3.1.5 Check the **high voltage** supply by pressing the **"HV"** switch.

Observe that the displayed reading is within +/- 25 (volts) of the value indicated on the calibration lab label that is attached to the instrument casing.

5.3.1.6 Check the **threshold** adjustment by pressing the **"THRESH"** switch:

Observe that the displayed reading is within +/- 25 of the value indicated on the calibration lab label.

5.3.2 Ambient Background Level Response

5,3.2.1 Before continuing, make sure that the pancake GM beta detectors are fitted with 1 cm standoff collars and that the two NaI gamma detectors are correctly mounted on a pole at 1 m distance from the end of the pole as described in paragraph 3.2.

5.3.2.2 Before starting the SDF survey, the survey team will select a location near the SDF Site that is free of contamination, out of the way of the work activities, and representative of the normal background radiation level for this geological area.

This location will be the designated spot for the daily instrument performance checks (at the beginning, middle, and end of each shift), and should be disturbed as little as possible while the radiological survey is in progress. Radioactive sources will be kept away from this location except when the survey instruments' responses to the field check source are being checked.

5.3.2.3 Carry the survey instruments to the location designated for ambient background level measurement. <u>Observe</u> the ground surface at the measurement location, and <u>crush</u> (e.g., flatten with a foot) or clear an approximately 4 in. x 8 in. area of any vegetation or debris that might damage the pancake GM detector windows.

5.3.2.4 Place the two pancake GM beta detectors side by side on the prepared ground surface, and place the end of the pole with the gamma detectors next to the two pancake GM detectors. During the measurement, the pole will be held perpendicular to the surface being measured.

5.3.2.5 Zero the digital meters of each of the four survey instruments by pressing the "ZERO" button. Initiate a 1-minute count for all of the instruments at the same time by pushing each of their respective "COUNT" buttons.

5.3.2.6 At the end of the one-minute count cycle, record the results of the count rate measurement (for all four instruments) in the IQR (see Appendix B) along with the identification data for the designated ambient background measurement location being used.

5.3.2.7 Repeat steps 5.3.2.5 and 5.3.2.6 for a total of two measurements of one-minute count data.

<u>Verify</u> that the resulting meter reading is within normal bounds.
(2000 to 4000 counts/min for ambient gamma at 1 m)
(60 to 120 counts/min for gross beta at 1 cm)

5.3.2.8 Reset the counting time function switches to 5 minutes and repeat steps 5.3.2.5 and 5.3.2.6 for a single measurement of 5-minute count data.

5.3.2.9 Record the results of the 5-minute count rate measurement in the IQR as before.

5.3.3 Designated Field Check-Source Response

5.3.3.1 Carry the survey instruments to the location near the SDF site that has been designated for ambient background level measurement. Make sure that the area is free from extraneous radioactive sources except for the designated field check-source.

Before the start of the SDF survey, the test set-up geometry (distance and relative orientation between the source and detectors) for testing the instruments' response to the field check source will be established by the survey team. The two gamma detectors should be checked together while still mounted to the pole. The two beta detectors should also be checked together, with their standoff collars still in place. The equipment set-up for the check will be noted in the survey logbook, and will be the standard for all subsequent field check source response tests during the SDF survey. The field check source used for the test will also be identified in the logbook, and the method that was used to evaluate the source's isotope content in the laboratory will be noted.

During this one-time standardization procedure, a series of three successive five-minute counts will be made of the instruments' response to the field check source. These values will be entered into the survey logbook along with the test set-up notes. The average value of these results will be used as the standard for comparing the instruments' performance in all subsequent check source response tests. The general procedure for measuring the instruments' response to the field check source is given in the following paragraphs.

5.3.3.2 Zero the digital meters of each of the survey instruments being tested by pressing the **"ZERO"** button. Initiate a 5-minute count for each of the instruments being tested at the same time by pushing each of their respective **"COUNT"** buttons.

5.3.3.3 At the end of the count cycle, record the results of the count rate measurement (for each instrument) on the IQR, along with the identification data for the designated ambient background measurement location being used.

5.3.4 Instrument Procedures for Survey Measurements

5.3.4.1 The location of each survey measurement point will be determined by the grid layout procedures given in paragraph 5.2.2.

5.3.4.2 The survey measurements to be obtained at each designated grid location will be two measurements of gamma activity at 1 meter distance from the ground surface, and two measurements of beta/gamma activity at 1 cm distance from the ground surface. All four measurements are to be made simultaneously with independent survey instruments. The counting period for these measurements will be 1 minute.

5.3.4.3 Make sure that the function switch settings are correct, that the calibration date has been verified, that the instrument performance checks are current and satisfactory, and that the RP&HPS Instrument Qualification Report has been properly completed (Appendix A).

5.3.4.4 Observe the ground surface measurement location, and crush (e.g., flatten with a foot) or clear an approximately 4 in. x 8 in. area of any vegetation or debris that might damage the pancake GM detector windows.

5.3.4.5 Place the two pancake GM beta detectors side by side on the prepared ground surface, and place the end of the pole with the two gamma detectors next to the two pancake GM detectors. During the measurement, the pole will be held perpendicular to the surface being measured, taking care that the gamma detectors are also at least 1 meter distance from other nearby rocks, cliff faces, debris piles, or the like.

5.3.4.6 Zero the digital meters of each of the four survey instruments by pressing the **"ZERO"** button. Initiate a 1–minute count for all of the instruments at the same time by pushing each of their respective **"COUNT"** buttons.

5.3.4.7 At the end of the 1–minute count cycle, record the results of the count rate measurement (for all four instruments) on the survey Data Control Sheet, along with the correct grid location identification data (Appendix B).

5.3.4.8 Observe that the meter readings from each of the two sets of duplicate instruments are consistent.

5.4 INSTRUMENT CALIBRATION AND FUNCTIONAL PERFORMANCE CHECKS

5.4.1 RP&HPS Quarterly Calibration

All survey instruments used in this study will be selected from among those maintained on a Quarterly Calibration cycle by the RP&HPS Instrument Lab. Further, the date of the last calibration for the selected instruments shall be no more than 45 days preceding the SDF survey start date.

The Pancake G–M beta (gamma) survey meters will be calibrated against a ^{99}Tc standard source. The NaI gamma survey meters will be calibrated against a ^{137}Cs standard source, and verified against both ^{241}Am and ^{226}Ra standard sources.

A copy of the Calibration Lab's Instrument Calibration report will be included with the report of the results of the work described in this DWP.

5.4.2 Special Low Activity Level Response Checks

In addition to the normal RP&HPS Quarterly Calibration, each of the survey meters used in the SDF survey will undergo a special performance check in the Calibration

Laboratory to check the instruments' responses to low–level radiation fields. These special quality assurance checks will verify the detectors' performance with radiation fields near normal background levels (comparable to the measurement range expected during the actual SDF survey). The special pre–survey and post–survey checks are listed in more detail in Appendix A.

5.4.3 Daily Functional Performance Checks

In order to ensure that data quality is sustained throughout this SDF radiological survey, checks on survey instrument functional operation will be performed at scheduled intervals. Additional performance checks may also be done whenever needed by the survey team.

5.4.3.1 Schedule for Performance Checks

While the field survey is ongoing, the following minimum schedule will apply:

1.	Instrument Voltage Settings Check	• Whenever the instrument is turned on after sitting idle. • At the start, middle, and end of the shifts.
2.	Ambient Background Level Response	• Whenever the instrument is turned on after sitting idle. • At the start, middle, and end of the shifts.
3.	Designated Field Check Source Response	• At the start, middle, and end of the shifts.

NOTE: The Ambient Background Level, and Field Check Source Response tests at the beginning, middle, and end of each shift will be done at the designated instrument check location near the SDF site.

5.4.3.2 Daily Work–Shift Checks

The following instrument performance checks will be performed at the beginning, middle, and end of each work shift.

5.4.3.2.1 Check the Instrument Voltage Settings and record the results on the RP&HPS Daily Instrument Qualification Report (See Appendix A).

5.4.3.2.2 Measure the Ambient Background Radiation Level at the designated instrument check location near the SDF site for the following count–time intervals:

1–minute count–time .... Make 2 separate measurements
5–minute count–time .... Make 1 measurement

Record the results of these Background Level measurements on the Daily Instrument Qualification Report.

Observe that the measured Background Radiation Level readings are within normal bounds.

5.4.3.2.3 Measure the instrument response to the Designated Field Check–Source for the following count–time intervals:

5–minute count–time .... Make 1 measurement

Record the results of the response checks on the Daily Instrument Qualification Report.

Observe that the measured response readings are within normal bounds.

5.5 CRITERIA FOR DETERMINING THAT ABOVE–NORMAL RADIOACTIVITY IS PRESENT

A survey location will be suspected of being radioactively contaminated if the measured ambient gamma exposure rate at 1 m height exceeds the normal background level by 5 μR/hr.

This criteria level was established at Rocketdyne for the Sodium Disposal Facility and its surrounding area during previous radiological surveys of the area (applicable document 3). The criteria was established in consideration of the USDOE "Guideline for Residual Radioactivity at Formerly Utilized Sites, etc." (applicable document 4).

5.6 DATA ANALYSIS

5.6.1 Conversion of Data to Activity and Radiation Units

5.6.1.1 Data that was recorded at the time measurements were made, shall be transferred to a computer spreadsheet. One spreadsheet should be created for each statistical sampling area (i.e., Upper pond, Lower pond, Western area, or Northern area). Columns shall be created to accept the following input data:

1. SDF area (Upper pond, Lower pond, Western area, or Northern area)
2. Sample location coordinates (referenced by distance to the reference brass surveyors monument)

3. Beta total 1–min count activity at 1 cm distance from surface for both instruments

4. Beta survey instrument (5 min) background count, efficiency factor (dpm/cpm), and area factor for both instruments

5. Gamma total 1–min activity at 1 m distance from surface for both instruments

6. Gamma survey instrument 5–min background count and efficiency/normalization factor for both instruments

7. Clock time and date when measurement was made.

5.6.1.2 Columns shall then be created to calculate the following output data for each instrument at each measurement location:

1. Average total beta activity at 1 cm distance from the surface, variance, standard deviation (dpm/100 cm^2), and the difference between duplicate instruments.

2. Average gamma total activity at 1 m distance from surface, variance, standard deviation, and the difference between duplicate instruments.

3. Ambient gamma exposure rate and standard deviation (μR/hr)

5.6.1.3 The net count rate observed for beta surface activity are converted to dpm/100 cm^2 by:

$$SA = (C_r - B_r) \times E \times \frac{100}{A}$$

where SA = net surface activity count rate at sample location (dpm/100 cm^2)

C_r = total count rate (cpm) at the sample location

B_r = normal background count rate (cpm)

E = detector efficiency factor, dpm/cpm

100 = 100 – cm^2 standard area

A = area measured by detector (20 cm^2)

5.6.1.4 To determine the standard deviation of the measurement, the analysis must be adjusted to account for differences in the precision between measurements of the background counts and measurements of the total counts at the sample location. The standard deviation of the measurement (in dpm/100 cm^2) is thus given by:

$$SD = \sqrt{\frac{C_r}{T_c} + \frac{B_r}{T_b}} \times E \times \frac{100}{A}$$

where SD = standard deviation of the measurement ($dpm/100\ cm^2$)
T_c = time allowed to measure the count rate at the sample location (1 min)
T_b = time allowed to measure the background count rate (5 min)

5.6.1.5 The ambient gamma exposure rate is calculated as follows:

$$\epsilon_\gamma = C_r R$$

where ϵ_γ = ambient gamma exposure rate (μR/hr) at the sampled location
R = exposure rate conversion factor for Area IV (μR/hr/215 cpm)
C_r = total count rate at the sample location
T = count time

Note that no adjustment for background is made and that the detector efficiency factor is included in the exposure rate conversion factor (R). The standard deviation of the exposure rate is then obtained as follows:

$$SD = \sqrt{\frac{C_r}{T}} \times R$$

After the data are entered into the spreadsheet and the calculated values are obtained, a disk file is created for storing the calculated values. A software program will then be used to read this file and to plot activities or exposure rates against the Gaussian cumulative distribution function on a probability scale. If the data follows a normal distribution, which is indicative of normal background, then the resulting plot will be a straight line. A resulting plot with a "dog–leg" line could be indicative of contaminated areas superimposed upon normal background data.

5.6.2 Statistically Significant Activity (SSA)

Count times must be chosen to ensure that the detection limits and/or statistically significant activities (SSA) are adequately low. SSA is a measure of the confidence that the activity observed is in fact due to contamination and is not due to the random variability of natural background activity. The SSA for any measured radiation can be expressed as:

$$SSA = \frac{f\sqrt{2B}}{T}$$

where B = the total background counts detected in T minutes
T = count time in minutes
f = confidence level factor
= 1.645 for one–sided 95% confidence level for assumed normal distribution.

5.6.2.1 Beta "Pancake" GM Probe

For a beta GM probe (for a normal counting efficiency of about 7.7) the background at SSFL is about 94 counts per minute (cpm). Thus, for a 5-minute count:

$$SSA = 1.645 \frac{\sqrt{2 \text{ x } (5 \text{ x } 94)}}{5}$$

$$= 10 \text{ cpm}$$

Thus, for a 5-minute pancake probe count, there is a 95% chance that a measured total activity of (94 + 10 =) 104 cpm indicates contamination. Likewise, there is a 5% probability that a measured total activity of 104 cpm does not indicate contamination but indicates only variation in natural background. SSA is one form of "detection limit." From the equation, SSA is proportional to the inverse square root of the count time. Thus, increasing count time will reduce the SSA or increase the "accuracy" of the measurement. Table 1 shows SSA as a function of count time, and shows that a 1-minute count time will provide sufficient "accuracy." The SSA can also be expressed in derived units as well as "cpm." By multiplying by the GM probe efficiency and area factor, the SSA can be expressed in dpm/100 cm^2; e.g., for a 5-min count,

$$10 \text{ cpm x } 7.7 \frac{\text{dpm}}{\text{cpm}} \text{ x } \frac{100}{20}$$

$$= 385 \text{ dpm/ } 100 \text{ cm}^2$$

Table 1. Statistically Significant Activity of GM Beta Probe

Count Time	SSA		Percent of Background
	cpm	dpm/100 cm^2	
1 sec	175	6738	186
10 sec	55	2127	59
1 min	23	868	24
5 min	10	388	11
10 min	7	275	8
Background	94	3619	

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5.6.2.2 NaI Gamma Probe

In the same way, SSAs for a NaI gamma probe can be calculated:

$$SSA = \frac{1.645\sqrt{2B}}{T}$$

For a 1–minute count:

$$B = \sim 3290 \text{ counts}$$

$$SSA = \frac{1.645\sqrt{2 \times 3290}}{1} = 133 \text{ cpm}$$

Thus, for a 1–minute gamma probe count, there is a 95% probability that measured <u>total</u> activity of (3290 + 133 =) 3423 cpm indicates contamination. SSA can be expressed in derived units of μR/hr by using the conversion factor 215 cpm/μR/hr as listed in Table 2. Table 2 shows that a 1–minute count will provide an SSA of ~0.6 μR/hr which is ~12% of the ambient gamma criterion of "5 μR/hr above background at 1 meter from the ground surface." Therefore, a 1–minute gamma count is appropriate to ensure sufficient "accuracy."

In the above analysis the term $\sqrt{B}$ has been used as an analytical expression of the standard deviation of the background count. Where a background survey is available, then the measured, empirical standard deviation of background must be used. This may be different than the analytical standard deviation.

Table 2. Statistically Significant Activity of NaI Gamma Probe

Count Time	SSA		Percent of Background
	cpm	μR/hr	
1 sec	1034	4.8	31
10 sec	291	1.4	9
1 min	133	0.62	4
5 min	60	0.28	2
10 min	42	0.20	1.3
Background	3290	15	

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In this survey, the background radiation levels will be measured, so that the precision of the measurement will be determined empirically. To estimate the effect of this difference, the data from recent measurements of background radiation levels at a nearby location within SSFL Area IV can be used to evaluate the effect upon the predicted SSA for 1 minute count time.

The actual data (from a location near Bldg. 100) shows an average background of 3288 cpm, with a standard deviation of ± 67 cpm. Factoring this experience into the SSA estimation for the 95% confidence level yields an SSA of 156 cpm, which would mean that a measured total activity of 3444 cpm would indicate a possible contaminated condition with 95% certainty. This provides a margin of sensitivity to the presence of isotopic activity that is sensitive to one–tenth of the level of the appropriate ambient gamma regulatory limit of 5 μR/hr above the background.

APPENDIX A
QUALITY ASSURANCE

A.1 ETEC Quality Assurance and Training department will provide independent QA oversite to assure effective execution of the requirements of this procedure through monitoring and surveillance of activities listed in Appendix A.

A.2 DAILY INSTRUMENT QUALIFICATION REPORTS

The Daily Instrument Qualification Report (IQR) is the document that is used to record the results of instrument performance checks. As such, it is the central quality assurance thread that traces the performance of the survey instruments, in quantitative terms, throughout the entire survey.

A.3 INSTRUCTIONS GOVERNING THE USE OF THE FORMS

The IQR form is shown in Figures 2 (beta) and 3 (gamma). One daily IQR form will be completed for each instrument used during each day of the survey. The IQR forms will be permanently attached to the survey log book at the beginning of each survey team work shift, and the results of performance checks will be entered on the IQR forms at least three times each shift: at the beginning of the work shift, at approximately mid–shift, and at the end of each work shift. The performance check entries for the beginning, middle, and end of each shift will be made at the designated Standard Background Level Check location near the SDF site (established by the survey manager).

Whenever instrument performance checks are entered onto the Daily Instrument Qualification Report, a notation remark about the check will be entered in the next available row on the Data Control Sheet currently being used (or in the first row, for the beginning of the work shift) (see Appendix B).

A.4 INSTRUCTIONS FOR COMPLETING THE DAILY INSTRUMENT QUALIFICATION REPORT

A.4.1 At the start of each work shift, the survey manager will provide the survey team with copies of the Daily Instrument Qualification Reports (IQR). The survey team lead will verify that a correct form has been provided for each instrument used in the survey. Identification data for the instrument electronics and detector hardware will be completely entered. Copies of the forms with completed manufacturer and RI asset ID data, "Scaler Diagnostic" CAL values, and "Field Check Source" ID data may be prepared in advance and reproduced to save time. The Survey Team Leader (the person who will actually lead the survey measurements) will check that the form IDs are entered correctly for the instruments used.

RADIATION PROTECTION & HEALTH PHYSICS SERVICES
BETA DAILY INSTRUMENT QUALIFICATION REPORT

INSTRUMENT ELECTRONICS

RI#: ______ S/N: ______

MFG: ______ Mdl: ______

RADIATION DETECTOR

RI#: ______ S/N: ______

MFG: ______ Mdl: ______

Det Eff Fctr: ______ dpm/cpm

CALIBRATION

Last Calibrated: ______ Next Cal Due: ______

FIELD CHECK SOURCE

Source ID: ______
Verified By: ______

Isotope | Energy | Activity

INSTRUMENT QUALIFICATION DATA

	@Shift Start:	@Mid-Shift:		@Shift End:
Check Time:				
SCALER DIAGNOSTIC (CAL)				
( ) BAT:				
( ) HV:				
( ) THRSH:				
BACKGROUND RESPONSE				
1-Min Count:				
:				
Calc Avg cpm:				
5-min Count:				
CHECK-SOURCE RESPONSE				
5-Min Count:				
Expected:				
*Calc E/F:				

DAILY AVERAGES

Check Source				Ambient Background		
Avg:	±	cpm		Avg:	±	cpm
Norm: Avg	±	dpm		Norm Avg:	±	dpm
Avg: E/F	±	dpm/cpm		Std Norm: Avg	±	dpm/100cm²

Completed By: Date: Project:

Figure 2. Daily Instrument Qualification Report (IQR) for Beta Survey Instruments

RADIATION PROTECTION & HEALTH PHYSICS SERVICES
GAMMA DAILY INSTRUMENT QUALIFICATION REPORT

INSTRUMENT ELECTRONICS		RADIATION DETECTOR	
RI#:	S/N:	RI#:	S/N:
MFG:	Mdl:	MFG:	Mdl:
		Det NormFctr:	

CALIBRATION

Last Calibrated: ______ Next Cal Due: ______

FIELD CHECK SOURCE

Source ID: ______
Verify By: ______

Isotope	Energy	Activity

INSTRUMENT QUALIFICATION DATA

	@Shift Start:	@Mid-Shift:		@Shift End:
Check Time:				
SCALER DIAGNOSTICS (CAL)				
( ) BAT:				
( ) HV:				
( ) THRSH:				
BACKGROUND RESPONSE				
1-Min Count:				
:				
Calc Avg cpm :				
5-Min Count:				
CHECK-SOURCE RESPONSE				
5-Min Count:				
Expected:				
*Calc E/F:				

Figure 3. Daily Instrument Qualification Report (IQR) for Gamma Survey Instruments

DAILY AVERAGES

Check Source

Avg: ______ $\pm$ ______ cpm

Avg: E/F ______ $\pm$ ______ cpm/µR/Hr

Ambient Background

Avg: ______ $\pm$ ______ cpm

Norm Avg: ______ $\pm$ ______ cpm

Avg Bkgd: Exposure ______ $\pm$ ______ µR/Hr

Completed By: Date: Project:

*Detctr Effcncy Factor = $\left[\frac{\text{(5-min Cnt)}}{\text{(Expected Cnt)}}\right] \times \left[\text{Det Normlzn Factor}\right] \times 215 = \left[\text{\_\_\_\_\_\_ cpm/µR/Hr}\right]$

A.4.2 The Survey Team Leader will affix the IQRs to the survey log and finish adding any of the preliminary entries needed.

A.4.3 The instrument meter readings from each work shift performance check will be entered onto the IQRs, starting with the checks at the beginning of the work shift. The clock time when the check is started will be entered next to **"check time"** in the appropriate Instrument Qualification Data (IQD) column.

A.4.4 Instrument Voltage Settings Checks

Record the meter readings for the instrument **"Voltage Settings Checks"** in the section labeled "Scaler Diagnostics." Enter each of the meter readings on a line next to the matching form heading in the appropriate IQD column. Compare the meter results obtained with the **"CAL"** values entered for the particular instruments, and verify that the measured values are within tolerance.

A.4.5 Ambient Background Level Response Check

Record the count values from the **Background Level Response Check** in the section labeled **"Background Response."** Enter the total count values on a line next to the matching count time **"(1 min)"** or **"(5 min)"** in the appropriate IQD column and verify that the measured values are within normal expectations. Calculate the average of the two 1-minute counts and enter the result next to the **"Calc Avg cpm"** heading.

A.4.6 Designated Field Check-Source Response Test

Record the 5-minute count values from the **Check-Source Response Test** in the section labeled **"Check-Source Response."** Enter the total count value on the line next to the matching heading in the appropriate IQD column. Enter the expected count value (from the standard average value determined in paragraph 5.3.3) on the next line, and calculate the estimated efficiency factor by the following equations:

beta:

$$\mathbf{E/F} = \left[\frac{\text{measured}\ \textbf{5-min count}}{\textbf{expected}\ \text{count}}\right] \times \left[\begin{matrix}\textbf{Det Eff}\\ \textbf{Fctr}\end{matrix}\right]^{*} = \left[\underline{\hspace{3cm}}\ \frac{\text{dpm}}{\textbf{cpm}}\right]$$

gamma:

$$\mathbf{E/F} = \left[\frac{\text{measured}\ \textbf{5-min count}}{\textbf{expected}\ \text{count}}\right] \times \left[\begin{matrix}\textbf{Det Norm}\\ \textbf{Fctr}\end{matrix}\right]^{*} \times 215 = \left[\underline{\hspace{3cm}}\ \frac{\textbf{cpm}}{\mu\textbf{R/Hr}}\right]$$

*Provided by Calibration Lab

A.5 INSTRUCTIONS FOR DAILY EVALUATION OF THE INSTRUMENT QUALIFICATION DATA ENTRY

A.5.1 Before the beginning of each work shift, the survey manager will inspect the data from the previous Daily Instrument Qualification Report to determine that there are no anomalous entries.

A.5.2 For each instrument, using the data from the previous day's IQRs, the Survey Manager will calculate the mean and standard deviation for all of the:

1–minute Ambient Background Response Checks
5–minute Check Source Response Checks
Calculated Survey Efficiency Factor Values (**"Calc E/F"**)

A.5.3 The results from A.5.2 will be normalized to adjust for the individual detectors' relative counting efficiency values provided by the Calibration Lab (gamma = **"Det Norm Fctr"**, beta = **"Det Eff Fctr"**).

$$\begin{bmatrix}\text{Daily } \textbf{Average}\\ \text{Ambient}\\ \text{Background}\end{bmatrix} \times \left(\begin{matrix}\textbf{Det ``Eff''}\\ \textbf{Fctr}\end{matrix}\right) = \begin{matrix}\textbf{Normalized}\\ \textbf{Average}\\ \text{Ambient Background}\end{matrix} = \begin{Bmatrix}\textbf{cpm}, \text{ for gamma}\\ \textbf{dpm}, \text{ for beta}\end{Bmatrix}$$

$$\begin{bmatrix}\text{Daily } \textbf{Average}\\ \text{Check Source}\\ \text{Countrate}\end{bmatrix} \times \left(\begin{matrix}\textbf{Det ``Eff''}\\ \textbf{Fctr}\end{matrix}\right) = \begin{matrix}\textbf{Normalized}\\ \textbf{Average}\\ \text{Check Source}\\ \text{Countrate}\end{matrix} = \begin{Bmatrix}\textbf{cpm}, \text{ for gamma}\\ \textbf{dpm}, \text{ for beta}\end{Bmatrix}$$

$$\begin{bmatrix}\text{Daily } \textbf{Average}\\ \text{Calculated}\\ \text{Survey } \textbf{E/F}\end{bmatrix} \times \left(\begin{matrix}\textbf{Det ``Eff''}\\ \textbf{Fctr}\end{matrix}\right) = \begin{matrix}\textbf{Normalized}\\ \textbf{Average}\\ \text{Survey } \textbf{E/F}\end{matrix} = \begin{Bmatrix}\dfrac{\textbf{cpm}}{\boldsymbol{\mu}\textbf{R/Hr}}, \text{ for gamma}\\ \dfrac{\text{dpm}}{\textbf{cpm}}, \text{ for beta}\end{Bmatrix}$$

A.5.4 The results from A.5.3, for the gamma data, will then be used to find the Average Background Exposure Rate for gamma:

$$\begin{matrix}\text{``Avg } \textbf{Bkgd}\\ \textbf{Exposure''}\end{matrix} = \left(\begin{matrix}\textbf{Avg}\\ \textbf{E/F}\end{matrix}\right)^{-1} \times \begin{bmatrix}\textbf{Avg}\\ \text{Ambient}\\ \text{Background}\end{bmatrix} = \left[\underline{\hspace{6em}} \frac{\mu\textbf{R}}{\textbf{Hr}}\right]$$

The results from A.5.3, for the beta data, will be used to find the Normal Average per 100 cm^2 Standard Area for beta:

$$\text{"Std Norm Avg"} = \left(\begin{matrix}\text{Norm}\\\text{Avg}\end{matrix}\right) \times 5 = \left[\text{\_\_\_\_\_\_\_\_\_\_} \frac{\text{dpm}}{100\ \text{cm}^2}\right]$$

A.6 "MEANS" CONTROL CHART FOR DAILY TREND ANALYSIS

The normalized daily check–source response count rates and average ambient background radiation levels will be plotted on daily "means" control charts throughout the duration of the survey. These charts will be monitored to watch for trends in instrument performance, as evidenced by trends in the data.

A.7 SPECIAL QUALITY ASSURANCE PRE–SURVEY AND POST–SURVEY INSTRUMENT RESPONSE CHECKS

In addition to the normal Instrument Lab calibration routines, each of the survey meters selected for the SDF survey will undergo the following special calibration routines not more than two weeks preceding the start of the survey and not more than one week following the end of the survey:

1. Designated Standard Lead Tunnel Checkout.
2. Designated low activity source response check.
3. Designated medium activity source response check.

A.7.1 Designated Standard Lead Tunnel Checkout

During the pre–survey instrument calibration, the detectors will be placed in a specially constructed enclosed lead brick tunnel, and the "quiet" background radiation level 5–minute count will be observed and recorded along with details of the Lead Tunnel construction. In all subsequent standard lead tunnel checks, the meter readings obtained will be compared to initial values for the test configuration, and will be entered in the instrument calibration report.

A.7.2 Designated Low Activity Source Response Check

While still enclosed in the lead brick tunnel, the detector will be exposed to a radiation source that has been attenuated so that the detector response can be observed at radiation field strength levels comparable to the low end of the normal background range (i.e., equivalent to about 2,000 cpm for ^{137}Cs gamma and about 60 cpm for ^{99}Tc beta). During the first pre–survey calibration, the 5–minute count value will be observed and recorded, along with details about the calibration source used, the distance and orientation from the detector, and the configuration of the hardware used in the test. In all subsequent checks, the meter readings will be compared to the initial values for this test configuration and entered in the instrument calibration report.

A.7.3 Designated Medium Activity Source Response Check

With the detectors still in the enclosed lead brick tunnel, the detectors will be exposed to a radiation source that has been attenuated so that the detector response can be observed at radiation levels comparable to about two times higher than the high end of the normal background range for Area IV (i.e., equivalent to about 8,000 cpm for ^{137}Cs gamma and about 240 cpm for ^{99}Tc beta). During the first pre-survey calibration, the count rate levels will be observed and recorded, along with the source and hardware details needed to duplicate the procedure in the future. In all subsequent checks, the meter readings will be compared to the initial values for this test configuration and entered in the instrument calibration report.

APPENDIX B
SURVEY RECORD KEEPING

B.1 SURVEY LOG BOOK

A log book will be maintained throughout the duration of the SDF preliminary radiological survey. Pertinent notes and explanatory comments about the survey will be entered in the log book to aid in later interpretation of the survey results. The **Daily Instrument Qualification Reports** (Appendix A) will be affixed to the log book at the start of each work shift. All measurement data from the survey will be entered on the **Survey Data Control Sheets** (next paragraph) which will also be affixed to the log book.

B.2 SDF PRELIMINARY RADIOLOGICAL SURVEY DATA CONTROL SHEETS

The SDF Preliminary Radiological Survey Data Control Sheets (Survey Data Control Sheets), Figure 4, will be used for recording all survey data from the work covered by this DWP. Each measurement at an individual sample location in the survey will occupy one row of the Survey Data Control Sheet. Each row of the sheet has columns for entering two gamma survey measurements plus two beta survey measurements. Space is provided with each set of paired measurement data to enter useful notes about the data levels being recorded by the duplicate instruments.

Additional space is provided to make relevant notes about the sample locations. The start time at each sample location will be noted in the space provided, which will be useful in developing work progress estimates for future surveys; the time notation will also serve as an aid to data evaluation if there is a marked daily march of changing background radiation (for example, associated with the location of the sun, or perhaps to temperature or humidity changes associated with the time of day).

Page:______of______.
Date:______________.

SDF PRELIMINARY RADIOLOGICAL SURVEY
DATA CONTROL SHEET

WEST LOCATION COORDINANT	NORTH/SOUTH LOCATION COORDINANT	CLOCK TIME		G1 GAMMA @ 1-M	G2 GAMMA @ 1-M		B1 BETA @ 1-cm	B2 BETA @ 1-cm		NOTES

Survey Completed By:____________________________

Figure 4. SDF Preliminary Radiological Survey Data Control Sheet